Identifying environmental and anthropogenic factors associated with sea star wasting disease through large-scale geospatial analysis

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Introduction

During summer and autumn 2013, sea star wasting syndrome (SSWS) spread to sites throughout the Pacific coast. While this disease has previously occurred on regional scales, an outbreak of this geographic extent has never been documented.

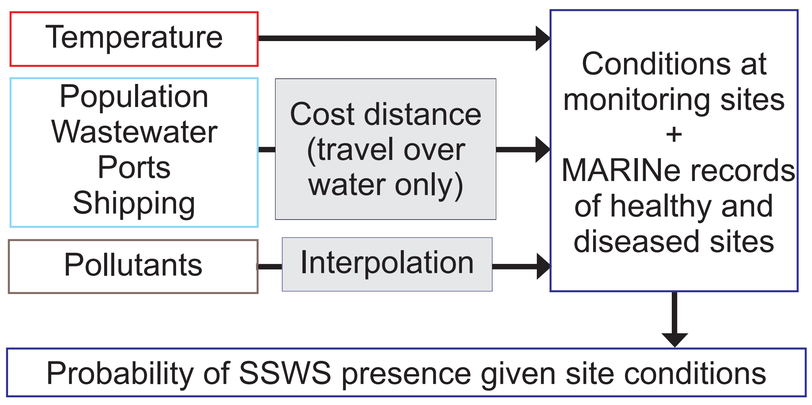
The causative agent responsible for SSWS is not yet known. Factors common to infected sites may aid the identification of the pathogen or conditions that increase susceptibility of sea star populations. GIS software allows a coast-wide analysis of which conditions are common in areas where the disease is present. Temperature, pollution, and coastal disturbance may act synergetically to influence disease occurence.

We aimed to identify the environmental conditions, both natural and anthropogenic, are common at sites with and without SSWS.

Materials and methods

In ArcGIS 10.2, we used interpolation and cost distance techniques to create rasters of temperature, pollutant, and anthropogenic factors within 50km of the Pacific Coast of North America for the following environmental factors:

1) Temperature anomalies (2013 vs. 1982-2008)
2) Distance to populations >1500 people/km^2
3) Distance from wastewater outfalls
4) Distance from major ports
5) Pollutants in sediment or mussel tissue (PCBs)
6) Distance from SO_2 emissions from shipping



Temperature anomalies included maximum deviation from the historical average, average deviation, and total degree heating days per month.

We used the Extract Values to Points function in ArcGIS to calculate the values of each factor at sites with and without SSWS present (disease data provided by PISCO/MARINe monitoring records).

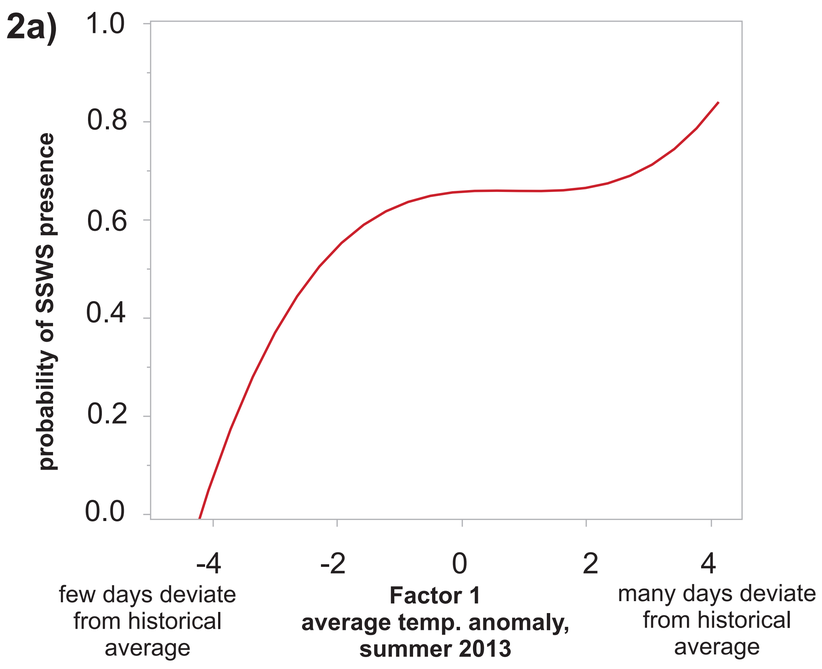
We used PCA to determine which covarying factors grouped into composite factors. We then tested which factors were correlated with SSWS presence and absence using logistic regression. No disease severity data was incorporated into the analysis.

Results

Average temperature anomaly positively correlated with SSWS incidence

Average monthly temperature anomalies for July-September 2013 aggregated into a single PC. Probability of SSWS presence increased as temperature anomalies increased until it plateaued after a threshold anomaly value (Fig. 2).

Average temperature anomalies for other months, maximum temperature anomaly, and degree heating days did not affect SSWS probability.



Distance from populated areas negatively correlated with SSWS incidence

SSWS probability decreased significantly with distance from areas with dense human populations and with distance from ports. SSWS incidence increased slightly with distance from wastewater outfalls (Fig. 3)

SSWS probability did not differ significantly with levels of PCBs in sediment or mussel tissue or distance from SO_2 emissions incidence.

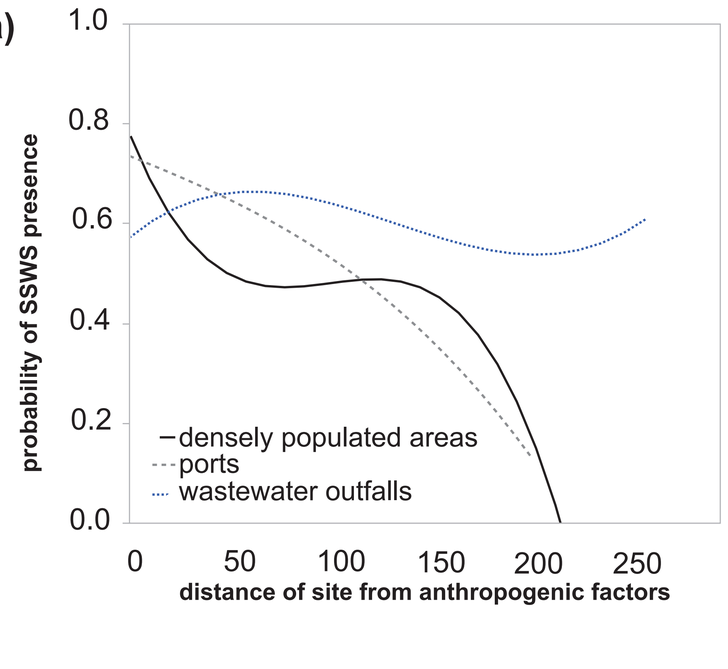


Fig. 2. **a)** SSWS probability was positively correlated with temperature difference from the historical average during summer 2013 ($p = 0.037$). **b)** Disease presence, absences, and average temperature anomalies for July to Sept. 2013 (°C).

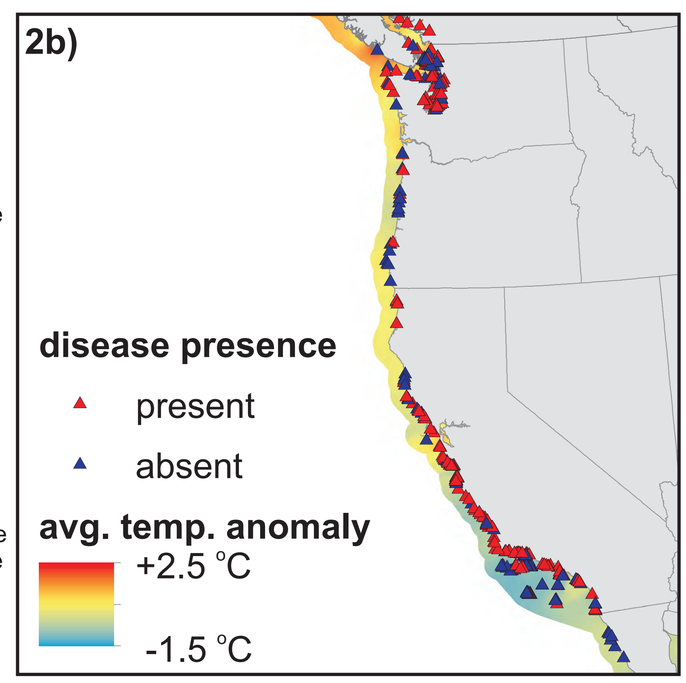
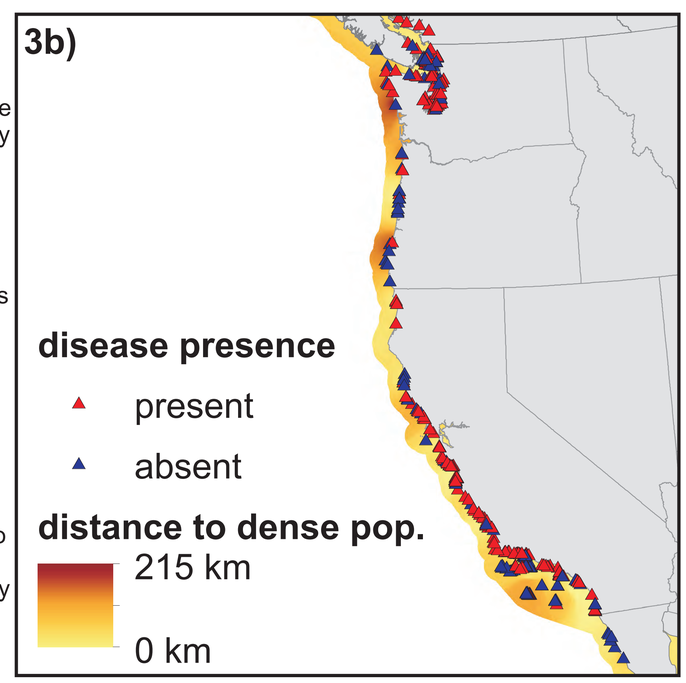


Fig. 3. **a)** SSWS probability with distance from densely populated areas (>1500 people/km^2, $p = 0.028$), coastal ports ($p < 0.001$), and wastewater outfall locations ($p = 0.016$). **b)** Disease presence compared to distance from densely populated areas.



Discussion

Higher disease presence in areas of above average temperatures, also observed in previous SSWS outbreaks, suggests a pathogenic cause of wasting syndrome. Higher temperatures increase growth rates of bacteria and other pathogens and stress sea stars, increasing their susceptibility to disease.

Higher disease presence near populated areas and ports but not wastewater outfalls suggests that anthropogenic disturbance plays a role in SSWS occurrence. However, the location of more disease reports near populated areas due to ease of access acts as a confounding factor.

Identifying which conditions are associated with SSWS can point to a cause and help predict which areas are at risk of infection, which is useful for directing monitoring efforts over large geographic areas.

Acknowledgments

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